Biodiversity Study

Problem How can you quantify the biodiversity of your field site?

Objectives

Students will be able to:

- Set up a quadrat and collect data at the site
- Calculate measures of biodiversity
- Write a scientific lab report

Pacing

Adapt the timeline below according to your needs.

Phase	Pacing	Student Tasks
Gear Up	20 minutes	Submit permission slips. Review procedures and behavior guidelines.
On Site	1 period, half block	Set up quadrats and collect data at the field site.
Analysis	1 period, half block	Organize and analyze field data. Calculate biodiversity.
Wrap-Up	30 minutes	Submit scientific lab reports.

Safety

Remind students of behavior expectations prior to leaving the classroom. Review hazards of the study site if necessary (wildlife, traffic concerns, poisonous plants). At least one adult should have student health and parent contact information if your field site is off campus. Follow school policy on the number of adults needed for off-campus fieldwork. Remind students to wear or bring attire that is appropriate to the study site and the expected weather. Students should wash hands or use hand sanitizer after completing the activity.

Materials

- Field notebooks
- Field guides
- Quadrat materials
  - Tape measure or meter stick
  - Wooden stakes
  - Twine
  - Mallet

eco • skill

SAMPLING: Counting every organism in a community or even in a single population can be a daunting, if not impossible, task. To get around this challenge, ecologists randomly select small portions of their study site for sampling. They record observations in a limited area and then extrapolating from those observations to produce population estimates about the site as a whole. Make the analogy between scientific sampling and sampling ice cream: A sample spoonful may be missing a chunk of chocolate, but for the most part it tells you how it tastes and what the ingredients are.

Gear Up

Teacher Prep

To best enable your students to focus on data collection and analysis, do the following before heading to the field study site:

☐ Preview the Site

- **Site reconnaissance** Visit the site ahead of time to ensure that it is appropriate for quadrat sampling. Consider using a Web-based virtual Earth browser to preview the field site.

☐ Consider the Variables

- **Seasonality** Consult local nature bulletins or a local wildlife expert to determine what seasonal or migratory species may be present or absent.
- **Mobile species** If your site has highly mobile animals that are likely to move in and out of a sampling area during data collection, have students plan ahead for how to account for this behavior in their data.
- **Abundant species** If there is a dense population of a certain species, students may need to estimate quantity. Review estimation beforehand.
- **Unique species** Does your site have a rare or invasive species? If so, find and share information about the species before heading outside.
- **Permission** Check with the proper authorities before placing quadrats.

☐ Maximize Time

- **Efficiency** It may be best to set up the quadrats ahead of time so students can focus on collecting data. Depending on the diversity of life at the site, you may need to narrow the study's focus to specific groups of organisms, such as "plant biodiversity" or "beetle diversity," so they don't need to spend hours counting every organism within a quadrat.
- **Team size** Assemble teams of 3 to 5 students before heading outside.

Student Prep

Help your students do the following before they head to the field:

☐ Review Content

- **Unit 1 field study** If they did not visit the site in Unit 1, follow the suggestions on pages 2–4 to prepare them for their first site visit.
- **Unit 2** Review the lesson in the text on biodiversity.

☐ Look Ahead

- **Understand procedures** Review the methods of sampling and data collection.
- **Plan ahead for data analysis** Review the data tables and sample calculations.
- **Review expected behaviors** Remind students how they are to behave in the field.

☐ Come Equipped

- **Return permission slips** Make sure students turn in signed permission slips.
- **Come equipped** Remind students to bring a field notebook, pencil, and any other useful tools such as digital cameras, calculators, or GPS receivers.

Resources

Choosing Appropriate Field Guides

Most libraries have field guides for different regional categories of plants and animals in North America, such as birds of the Northeast or wildflowers of the Southwest. Once your available resources are identified:

- Look for field guides written for your specific area or state.
- Look for books with species students are likely to find at your study site, such as mushrooms of Pennsylvania or beetles of California.
- Online field guides can be useful if students have easy Internet access and can refer to detailed sketches or digital images of their organisms. Some online guides have been formatted for use on mobile devices such as phones.

Local Resources for Scientific Classification

If field guides are too general to identify unusual species:

- Call (or have students contact) a park ranger at a nearby state park for help identifying a particular species.
- Ask a biology professor at a local college.
- Submit an image of the specimen to an online forum that welcomes species identification questions.
- Zoos, museums, nature centers and botanical gardens often have resources for teachers, including libraries of materials that can be checked out.
- State conservation departments' Web sites are another great resource for information on plants and animals, particularly invasive species that have become a problem.

HOW TO

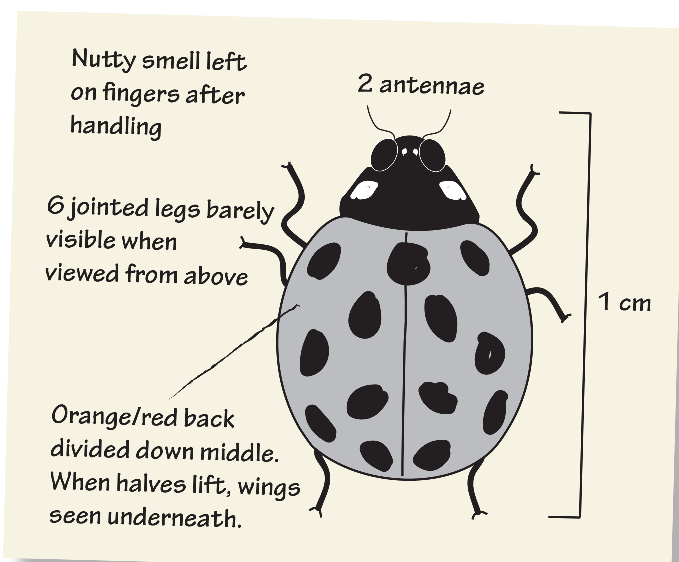
Sketch Organisms in the Field

Briefly go over good practices for sketching organisms in a field notebook. Even if field guides and digital cameras are available, ask students to sketch at least one of the species they find in their sample quadrats. Things to capture in sketches include:

- Outline of all major parts and coloration, including labels to remind students what colors were visible if colored pens or pencils aren't available
- Notes on any behaviors displayed by the organism
- Approximate size of the organism

Materials:

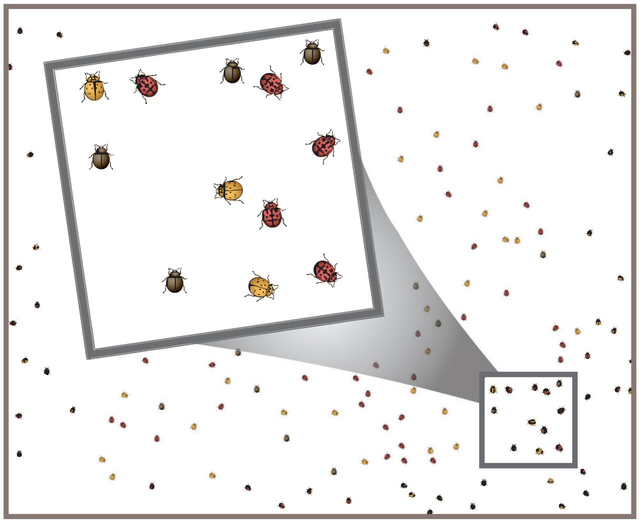
- Field notebook or paper
- Pencil or pen
- Ruler
- Magnifying glass (optional)



On Site

Sampling Method

Ecologists sample an area rather than collect data from an entire site In this study, you will use the quadrat method to collect biodiversity and population data.



what's a quadrat?

A quadrat is a square sample area, or plot, often measured and marked off with stakes and twine. All organisms, or all members of a predetermined group of organisms, within the quadrat are identified and counted. These data are then extrapolated to estimate the biodiversity and populations for the whole site. In the example shown here, a quadrat has been placed in an area swarming with beetles. If 12 beetles are within the quadrat (inset), then the total population can be estimated by comparing the quadrat area to the area of the site.

HOW TO

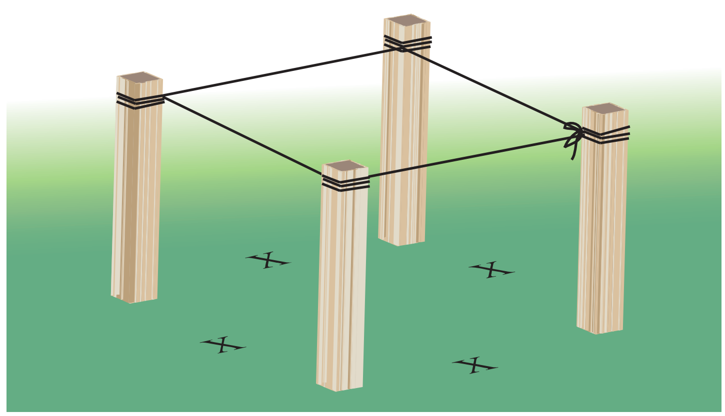
Set Up the Quadrat

Select a quadrat size. Anything from 1 m^2 to 9 m^2 may be appropriate, depending on the size of your field site, the number of teams, and the anticipated biodiversity. Provide materials for one quadrat per student team. If portable one-piece quadrats are available, use those to minimize set-up time.

- Be sure the students place their quadrat randomly, without targeting a particular species or patch of land. To avoid confusion during data collection, do not allow overlapping quadrats. Have teams mark off their own quadrats by pounding the stakes into the ground in a square shape, with each side of the square—the space between two stakes—a uniform length, such as 1 meter for a 1 square meter quadrat.
- If quadrats will be left in place overnight, mark them with brightly colored ribbon or string. Post signs (laminated or weather proofed) describing the students' work to alert other people to the purpose of the quadrats.

Quadrat Construction Materials (per team)

- Tape measure or meter stick
- Wooden stakes, dowels, or paint stirrers (4)
- Cord or twine (see diagram)
- Hammer or mallet (if necessary)
- Colorful ribbons (optional)



Quantifying Organisms

Count

When studying large plants, ecologists count any plant that has some part within the quadrat. With moving animals, ecologists decide how they will count before they begin data collection. If there aren't a lot of organisms moving this way and that, then all animals with some part of their body in the quadrat can be counted. If there are hundreds of animals moving about, such as aphids crawling on a bush, ecologists will estimate how many are within their quadrat at any given time. If counting extremely abundant individuals, such as blades of grass, suggest sampling a subsection of the quadrat, such as 1/16 of the total area, and then multiplying the subsection's data by 16 to estimate populations for the entire quadrat.

Photographs are great for identifying organisms, but so are sketches. Refer to the "How to Sketch..." section in Gear Up.

Categorize

Ecologists count and identify individual species. To save time, have students count and identify organisms at a higher taxonomic level. For example, have them count beetles (Coleopterans), grasshoppers and crickets (Orthopterans), and aphids (Homopterans) instead of the specific species.

Collect or Observe

There are several options to help students get a close-up look at an organism while deciding how to classify it. Ecologists carry field guides and magnifying glasses or collect samples called vouchers for identification back at the lab. If you do not want your students handling organisms or taking them back to the classroom, have them take photos or draw sketches instead. If the study site features habitat that is hard to get into, such as tall grass, provide an insect net for students to "sweep" their quadrat. Tell students to release any captured organisms near the quadrat after they've been identified and tallied. If a quadrat encompasses a tall tree, provide binoculars so students can survey the upper branches.

Recording Data

Have each team count the number of individuals per species (or other assigned category) in their quadrat. For species verification back in the classroom, have them include sketches or photographs of each species. Each student should produce a tabular record of the data from their quadrat. The table shown here is an example of data where insects were the focus but identification was limited to generic groups.

Organism	No. of Individuals	Observations/Details
Field crickets	5	Scattered randomly around quadrat
Lady beetles	14	Found on woody plant
Black ants	25	Most found near ant hill

Analysis

Back in the classroom, students will organize and analyze their data. The calculation outlined below will provide a measure, or "index," of biodiversity at the site.

tips & techniques

Walk students through the calculation of the Simpson Index, showing them at each step how the field data relate to the equation.

Calculating Biodiversity

To quantify biodiversity, many ecologists use the Simpson Index. The equation for calculating the Simpson Index (D) is:

$$D = 1 - \left[\frac{\sum n(n-1)}{N(N-1)}\right]$$

The closer D is to 1, the higher is the biodiversity. The equation may look daunting, but all you need is the field data on the organisms that were identified and how many were counted. Organize your data as shown here:

Organism	No. of Individuals (n)	n - 1	n(n - 1)
Field crickets	5	4	20
Pill bugs	4	3	12
White grub	1	0	0
Lady beetles	14	13	182
Black ants	25	24	600
	N = Sum of all the n values above = 49		$\sum n(n - 1)$ = Sum of all the $n(n - 1)$ values above = 814

The first two columns are the same as in your field data table. The third column is for subtracting 1 from the value in the second column. The values in the fourth column are the products of columns 2 and 3. For example, in the first row, for field crickets:

$$n(n - 1) = 5 \times 4 = 20$$

All of the products in the fourth column are added together to get the value of $\sum n(n - 1)$, which is the numerator of our Simpson Index equation. For example, using the data above:

$$\sum n(n - 1) = 20 + 12 + 0 + 182 + 600 = 814$$

Meanwhile, the denominator of the equation is simply the total number of all organisms—the sum of all the n values in the second column—multiplied by that sum minus 1. Using the data above, $N(N - 1)$ is 49×48.

The equation then becomes very easy to use:

$$D = 1 - \left[\frac{\sum n(n-1)}{N(N-1)}\right] \quad \text{becomes} \quad D = 1 - \left[\frac{814}{49(48)}\right] = 0.65$$

Calculating Population Density

In addition to biodiversity, ecologists study individual populations to determine the health of the species and the community. This often involves calculating a population's overall density as well as its relative density.

Have teams compile their data and calculate the population density and relative density for each species sampled at the field site. To get started, draw a chart on the board for each species sampled at the site, as shown below, and have each team fill in the columns.

Quadrat	Number of Grubs	Area of Quadrat
Group 1	25	1 m^2
Group 2	6	1 m^2
Group 3	16	1 m^2
Group 4	0	1 m^2
Totals	47	4 m^2

Population Density is the number of individuals of one species per unit of area or volume. For example, using the sample data from Group 1 shown above:

$$\text{Population density} = 25 \text{ grubs} \div 1 \text{ m}^2 = 25 \text{ grubs/m}^2$$

To calculate the population density from aggregated data, divide the sum of all populations by the sum of the areas that were sampled. For example:

$$\text{Population density} = 47 \text{ grubs} \div 4 \text{ m}^2 = 10.18 \text{ grubs/m}^2$$

Relative Density is the population density of one species given as a percentage of the combined population densities of all sampled species, usually those of a similar type. For instance, the population density of the grub might be compared with the overall population density of all small arthropods sampled at the field site. For example:

Population density of grub = 10.18 per m^2
Population density of centipede = 8 per m^2
Population density of pill bug = 34.5 per m^2

$$\begin{aligned}\text{Relative density of grub} &= [10.18/\text{m}^2 \div (10.18/\text{m}^2 + 8/\text{m}^2 + 34.5/\text{m}^2)] \times 100\% \\ &= [10.18 \div 52.23] \times 100\% \\ &= 0.1949 \times 100\% \\ &= 19.49\%\end{aligned}$$

Thus, 19.49% of the arthropods sampled were grubs.

OVERVIEW GEAR UP ON SITE ANALYSIS WRAP-UP

Wrap-Up

Guidelines

Each research team will produce a scientific lab report, much like ecologists submit articles to scientific journals. Each article should include the following sections:

- **Abstract** High-level description of the results and their meaning
- **Background** Background information about community biodiversity and the study site
- **Materials and Methods** List of the materials, outline of the procedures used to collect data, and description of the methods used to analyze the data
- **Results** Presentation of the data in a clear and organized way; often involves data tables, graphs, and images; does not include explanations or conclusions
- **Discussion** Discussion of the results and why they are important; can list sources of errors, applications, and possibilities for future research
- **References** List of any references used, including field guides and reliable Web sites

tips & techniques

Provide guidelines to your students on which references are to be used and which are to be avoided.

Study Rubric

	4	3	2	1
Fieldwork	Conducted research professionally	Generally stayed on task; quality data	Some difficult in following guidelines; required intervention	Difficulty listening and working with others; impeded data collection
Teamwork	Contributed equally to the finished team project; collected data	Assisted with data collection and the final project	Completed individual tasks; did not assist with final project	Contributed little to the group effort
Data Collection	Carefully collected and organized data, following procedures	Collected data according to procedures	Collected some data, but did not analyze or organize them well	Collected little or no data; relied on the work of others
Analysis	Thoroughly analyzed data; calculations are accurate	Calculated results according to the outlined examples	Calculated results with some errors	Incomplete calculation of results
Lab Report	Report is well written; clearly expresses the data in formal format	Report includes all sections of the formal format	Report covers most sections; conclusions inaccurate	Conclusions missing; information inaccurate; informal formatting

Extensions

Consider having individual students or teams extend the field experience further:

- Collect bird data for submission to a citizen bird count.
- Create a database, Web site, or virtual Earth browser presentation.
- Conduct the same study in a different location with similar habitat—such as a backyard—and compare the results.
- Find Simpson Index values from real-world habitats such as tropical rain forests and coral reefs. How does the biodiversity of the field site compare to those places?

